COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

January, 1943

Twenty years' advance in traveling-grate stokers; The large streamlined unit at right has nearly four times the grate surface as that on the left.

Power, Steam, and Other Services at WILLOW RUN ▸

Superheat as a Factor in Design of Steam Generator Units ▸

Analysis and Testing of Coal ▸

COMBUSTION
DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME FOURTEEN NUMBER SEVEN

CONTENTS

FOR JANUARY 1943

FEATURE ARTICLES

EDITORIAL

DEPARTMENTS

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EDITORIAL

Power for 1943

It has long been a practice with many business papers and technical or industrial magazines to devote their January issues to a review of events, accomplishments and trends in their respective fields during the preceding twelve months and, with this background, to attempt forecasts for the ensuing year. In normal times this "stock taking" of progress served a useful purpose, although the selection of January was probably more traditional than logical, for engineering developments recognize no calendar dates and industry cycles are often coincident with other seasons.

This January, however, marks a year of the country at war, the effects of which have permeated every field and drastically altered our whole economic structure. The transition of a population from peacetime pursuits to all-out war effort has involved so much that is abnormal, and military demands of the future are so uncertain, that predictions for any field may be nullified by changes in any one of a number of factors.

Although we have witnessed an assumed abundance of many raw materials develop into acute shortages that have gravely affected most lines, it has been possible, so far, to meet all the essential power demands of a vast production program of war materials. This has been accomplished despite the bottleneck in steam turbines, restrictions on the use of steel and copper for power equipment, and the fact that new utility capacity is very much less than that projected some time ago by the Federal Power Commission as essential to the war effort.

The problem has been met by the integration of existing facilities, greater use of reserve capacity, the shifting of equipment from plant to plant and a greatly increased use factor of installed capacity through the employment of multiple shifts in production. Also, many new war plants have been equipped with their own power plants, others were converted from peacetime manufacture to war production without requiring additional power facilities, and much used power equipment has been reconditioned and again placed in service. This has eased the demand on public utilities. In fact, according to data compiled by the Edison Electric Institute, the margin between total generating capacity and the sum of the noncoincident peaks for December 1942 was slightly greater than that of December 1941, and approximated that for 1929. Thus it has been possible to spare power equipment for certain of our Allies through the diversion of some new capacity on order and through the dismantling and transfer of such reserve units as could be spared.

In meeting this situation, a very creditable job in making the most of what was available has been done through close cooperation between the Power Branch of the War Production Board and both the utilities and the industrials concerned. Obviously, it has often been necessary to sacrifice desirable engineering features and economy to expediency, but thus far, the earlier predictions of the Federal Power Commission as to a threatened power shortage have not been borne out.

Bearing in mind that our rate of production by the end of 1942 had attained a tremendous volume, that we will soon be meeting full war production schedules, that relatively few additional war plants remain to be built, that approximately five million kilowatts of new power capacity will be available in the next two years and that curtailment of non-essential load represents a reservoir as yet scarcely tapped, the power situation would appear to be well in hand.

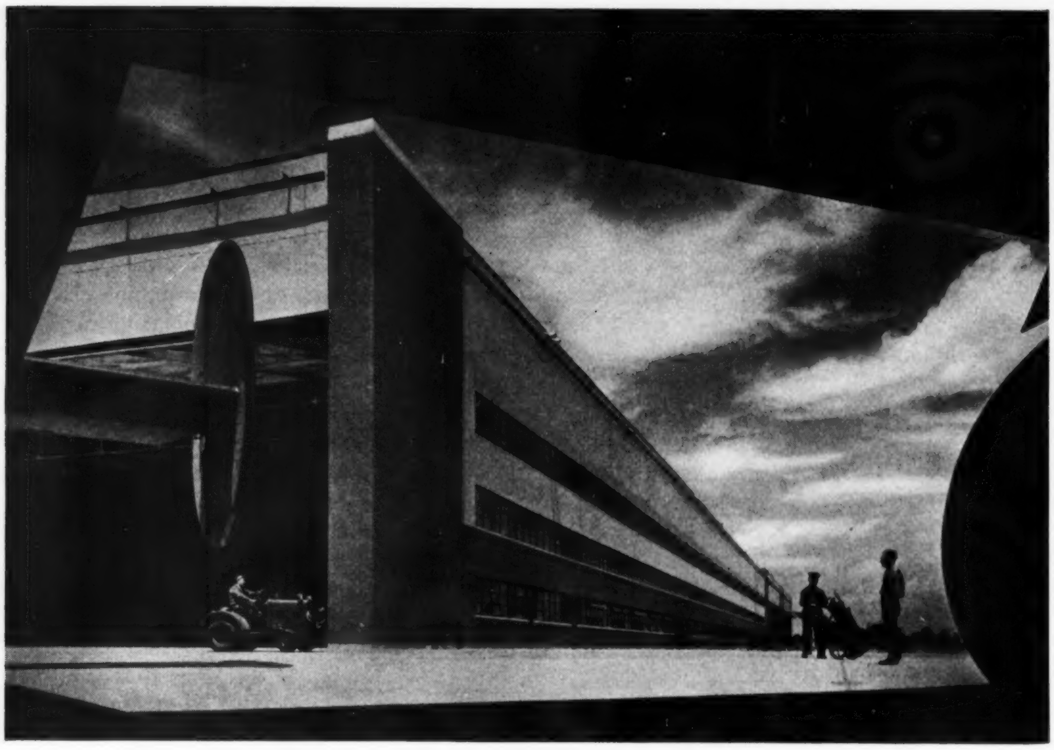
This, of course, presupposes that production schedules are not greatly enlarged, that maintenance is kept up, that the reduced reserve capacity in some localities will be adequate to meet unforeseen outages, that certain districts, dependent on hydro power, are not affected by droughts and that adequate fuel supply is available.

The shortage of oil in the East is likely to last for the duration, and although this has been offset to a considerable extent by the many conversions already made to coal, further conversions will be necessary. But assurance comes from the Office of the Solid Fuels Coordinator that the coal supply is adequate for the present; and this should continue to be so, barring a breakdown in transportation or labor troubles at the mines. Moreover, utilities and many large industrial plants have sufficient coal in storage to carry them over a temporary interruption in supply, the utilities having doubled their usual storage. Also, if the miners can be induced to accept a longer working week than the present one of 35 hours, the coal supply would be further fortified.

The fuel situation, however, has little direct bearing on the question of whether or not additional capacity is needed, although it is a factor with respect to getting maximum capacity out of existing equipment in cases where it becomes necessary to burn inferior grades of coal.

On the whole, the power supply outlook for 1943, while not definitely predictable, is reassuring; although well-informed Washington observers now hint that the recent shifting of responsibilities and personnel, because of conflicting views on power matters, may result in repronouncement of the Federal Power Commission's views on power shortage. It is to be hoped that this controversy will not be revived, for if any power shortages should occur they are likely to be local in character and can probably be met by local expedients.

Power, Steam, and Other Services at WILLOW RUN



Looking toward one end of final assembly

IT WAS a little more than a year ago that the late Albert Kahn and his associated architects and engineers were called in by Charles E. Sorensen, of the Ford Motor Company, and told, in effect:

"We have been asked to manufacture parts for a bomber and it seems likely that we'll also build complete bombing planes. The job will be like this."

Pointing to a layout of photographs of the Consolidated B-24 bomber in various stages of construction, he continued:

"I believe that with the open skeleton method, we could install plumbing and wiring, thus reducing the amount of inside work to a minimum, and that we can install an assembly line system with the center wings on a conveyor. With mating bucks at three or four stations, we should be able to attach the center, tail and nose sections and then put her on her own wheels."

Mr. Sorensen then sketched roughly what he thought would be the best system of handling the various materials and asked that studies be made for a plant to manufacture both airplane assemblies and complete bombing planes under a single roof.

For the following notes on the Ford Bomber Plant we are indebted to Albert Kahn Associated Architects & Engineers, Inc. of Detroit who designed and supervised the building of this outstanding war plant. Details on the boiler plant were supplied by P. Preuthen and those on the heating system by G. Whittaker, both of this organization. The general contractor on the work was Bryant & Detwiler Company. Approval of the article for publication has been given by both the Public Relations Division of the War Department and by J. W. Thompson, Director of the Ford News Bureau.

Today Willow Run is one of the marvels of production genius. While slightly different from what Mr. Sorensen originally conceived, the difference is chiefly in size, for the completed plant embraces a total floor area of over four million square feet and the main manufacturing and assembly building alone covers approximately 70 acres. This is in addition to a huge hangar covering 15 acres, a large two-story office building, a two-story training school building containing class-rooms, laboratories and a lecture hall, a two-story personnel building, a commissary building containing kitchens that prepare box lunches for 80,000 workers, the power plant and numerous other service buildings.

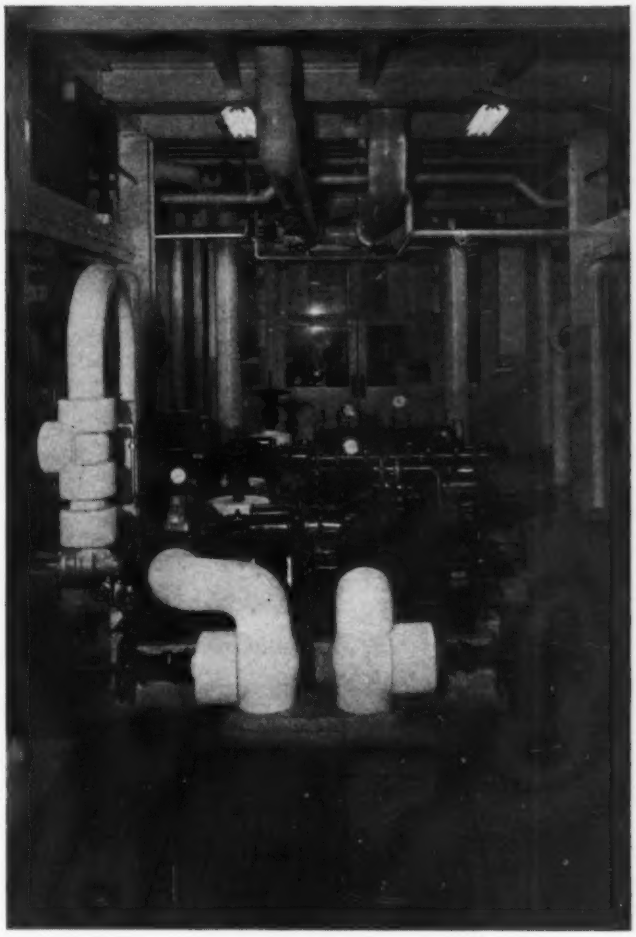
The main building is of steel and brick construction and of the semi-blackout type with no daylight in the production areas, fluorescent lighting being employed throughout and requiring 156,000 such lamps. The steel sashes in the various exterior elevations are

so placed as to provide light and ventilation for the respective factory offices and utilities which are located next to the outside walls of the first, mezzanine and second floors. However, because of the height required by the traveling cranes for handling huge parts, the production areas are single story. A two-story unit at one end of the building houses a material testing laboratory, pay offices, hospital, maintenance and safety offices, a kitchen, cafeteria and dining rooms, Government offices and the ship engineering design department.

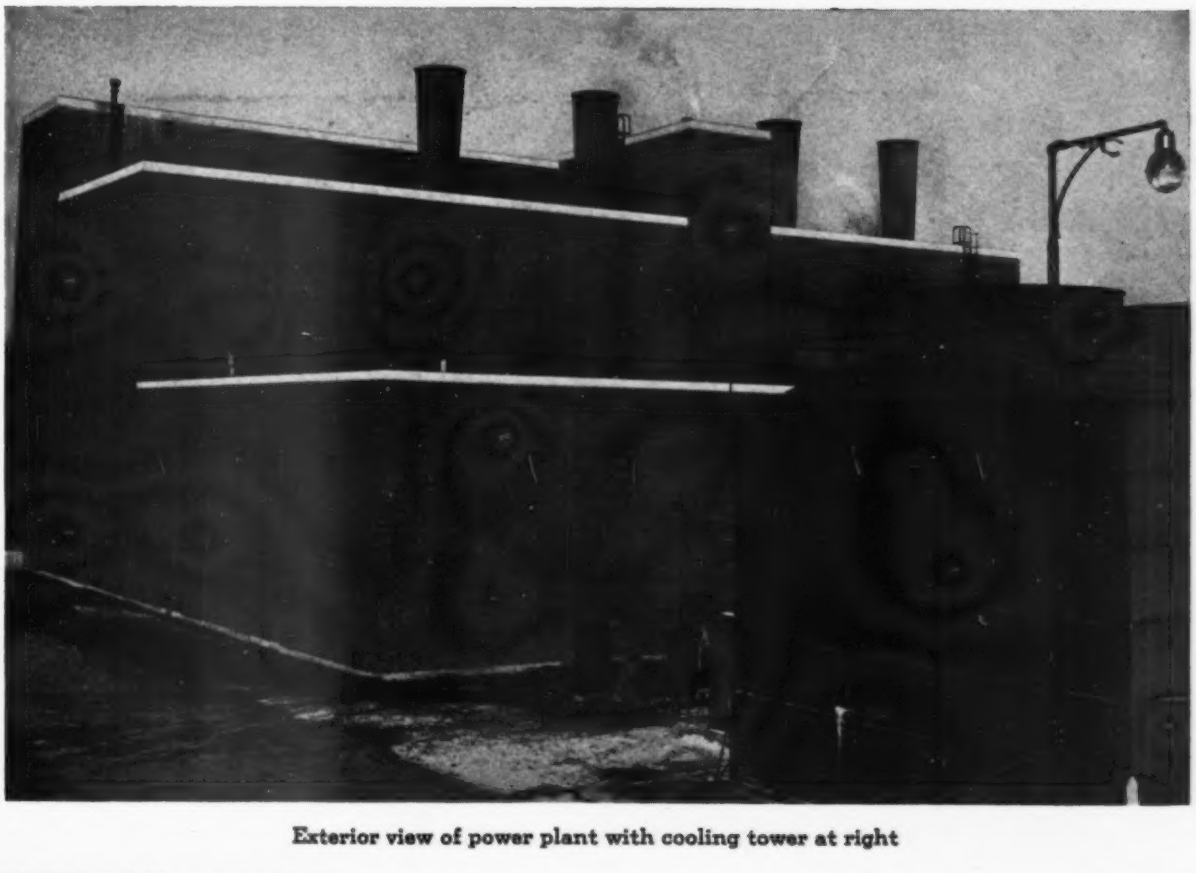
The final assembly lines occupy two 150-ft clear space bays running the entire length of the main building. Completed ships roll out onto a test field crossed by a number of runways, some of which are more than a mile long.

The foregoing rather brief description of this huge undertaking will serve to give some conception of the power, steam, air and other services required. To mention a few, there are sixteen pump rooms in the main building, two in the hangar and one in each of the other principal buildings. Sixty-five fan rooms in the main building, each handling from 35,000 to 100,000 cfm, account for 570 fans and there are 100 unit heaters serving the production areas. Chilled drinking water requires two 400-ton refrigerating compressors with cooling towers for condensing purposes; there is a vast fire protection system and a sewage disposal plant designed to accommodate a population of 100,000, with a separate system for handling corrosive and dangerous process waste.

Heating, ventilating and air conditioning for the different buildings are of various types, selected to give



Boiler feed pumps

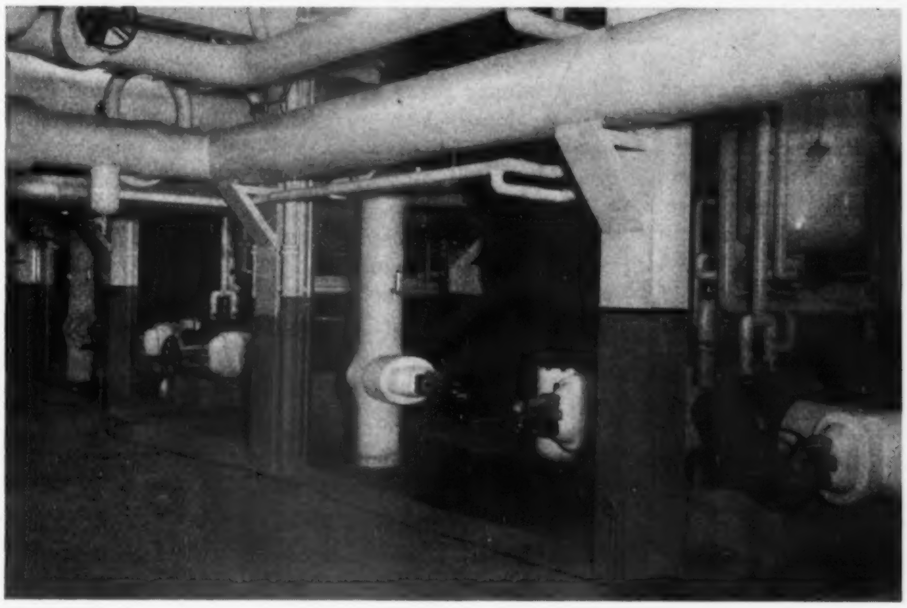


Exterior view of power plant with cooling tower at right

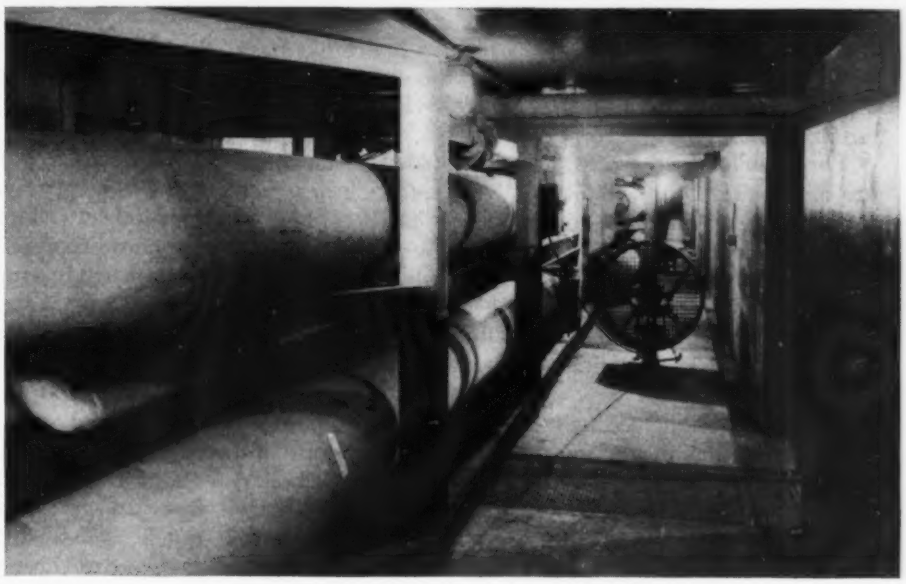
View of main switchboard

Turbine-generators and air compressors

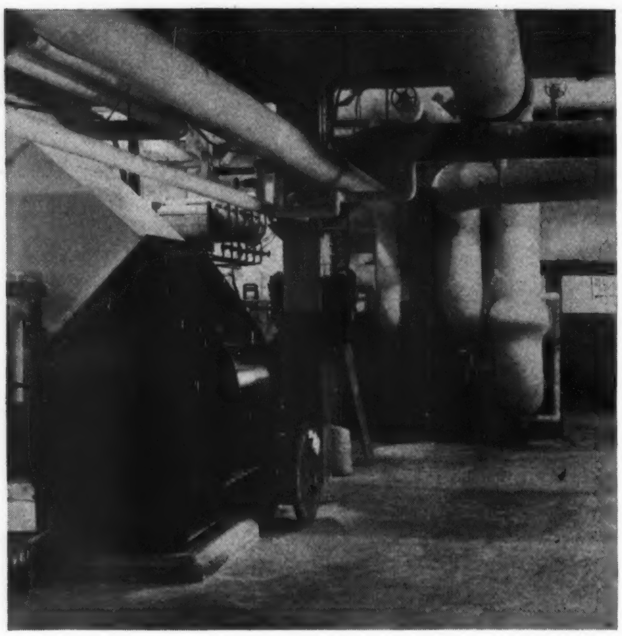
Operating floor of boiler room



Condensers and circulating pumps in basement



Tunnel containing steam and service lines



Entrance to pipe tunnel with fan at left

the most satisfactory and economical results in each case. For instance, a hot-blast system, under thermostatic control, serves the factory, combined hot-blast and radiators heat the engineering section, and radiators alone are placed in the offices, laboratories, hospital, etc. While some cooling of rooms is now employed, provision has been made for cooling the entire plant in the future, should this be desired, in which case 14,000 tons of refrigeration would be necessary.

Some 5000 ft of underground tunnels carry steam lines of 200,000 lb per hr capacity at 50 lb pressure from the power house to the various buildings, all condensate being pumped back.

Electric power is supplied by duplicate and widely separated 120-kv utility lines to underground substations. These are supplemented by two 2500-kw turbine-generators in the power house.

Power Plant

The boiler room contains four oil-fired units, each capable of producing 100,000 lb of steam per hour at 250 psi pressure and 50 deg superheat. Space has been provided for a fifth unit should this become necessary. Both forced and induced draft are provided, as well as automatic combustion control.

Three boiler feed pumps are installed, two of which are motor-driven and one turbine-driven, each designed to discharge against a head of 750 ft at 235 F.

The deaerating feedwater heater consists of a horizontal storage tank with cast-iron deaerating trays mounted inside the shell of the heater tank. It is designed to heat a total of 400,000 lb of water per hour of which 340,000 lb is condensate returns and 60,000 lb raw makeup.

Chemical treatment consists of tannin solution pumped into the suction header of the boiler feed pumps and phosphate fed directly into the rear drum of each boiler.

Steam is supplied at 250 psi pressure to two 2500-kw 3600 rpm turbine-generators designed to operate condensing with 27-in. vacuum and extraction at 50 psi. Full-load steam requirements when operating condensing are 33,900 lb per hr and 69,800 lb per hr when operating extracting at 50,000 lb per hr. This quantity of extracted steam from each turbine, or 100,000 lb in all, is supplied to the factory for process and heating and any deficiency is made up by live steam from the boilers through reducing stations. Water for the surface condensers is supplied by 4000-gpm pumps taking their supply from a 15,000-gpm cooling tower.

The turbine room also contains eight motor-driven rotary air compressors, each with a capacity of 1630 cfm of free air and supplying the system at 100 psi for manufacturing operations.

The power plant was designed by Albert Kahn Associated Architects and Engineers in close collaboration with William W. Dulmage, Superintendent of Power of the Ford Motor Company.

Facts and Figures

It is reported that the TVA now employs, in its various branches, a total of nearly 40,000 individuals.

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Just twenty years ago the first central station in this country, designed to operate at 400 psi steam pressure, went into service.

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The Department of the Interior reports the bituminous coal and lignite production for 1942 as 576 million net tons. This was an increase of 13 per cent over 1941 and nearly equaled the 1918 record production of 579,386,000 tons.

•

The capacity of electric generating stations in the United States, as of November 30, 1942, was 46,409,115 kw and the output for the twelve months ending on that date was over 183 billion kilowatt-hours, an increase of 12.7 per cent over the preceding year.

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Fuel consumption of the 1200 psi, 740 F reheat power plant in the steamship *Examiner* showed an improvement of about 13 per cent over a 425 psi, 740 F installation, during seven months' operation.

•

Canada is reported as having initiated construction of a hydroelectric development rated at over a million horsepower, which capacity will eclipse that of Boulder Dam and represent the world's largest power plant. Its output will be employed in aluminum production, but for reasons of war its location has not been given out.

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Tests conducted by the Bureau of Mines indicate that the heating values of most coals suffer relatively little from storage. Higher rank coals lose a maximum of about 1.2 per cent during the first year and 2.1 per cent in two years; whereas the lower rank coals may lose as much as 2 to 3 per cent in the first year and up to 5 per cent in three years.

Superheat as a Factor in Design of Steam Generating Units

By L. J. MARSHALL

Combustion Engineering Company, Inc.

From the turbine designer's standpoint a wide range of superheat control is desirable. What this involves, especially where other limiting conditions are specified, is pointed out; and the relation of superheat temperature to the various factors entering into the design of a steam generating unit are discussed broadly with the idea of better acquainting the user with some phases of the problem, where high steam temperatures are concerned.

WITH THE advent of the regenerative cycle and the use of 400 to 500 psi steam pressure and 750 F steam temperature no radical changes were required in the then conventional boilers, superheaters and furnaces. Designing a steam generating unit at that time consisted of selecting a boiler from tabulation of standard sizes and arranging a superheater without affecting the boiler design. Later when pressures and steam temperatures were increased it became impractical to use standard designs and at present almost every central station unit and many industrial units are individually designed for a particular set of conditions. When standardized boiler units could and were used the boiler itself was the all important part of the unit. Superheater economizer and air heater, if used, constituted only incidental parts of the entire unit. The surface of the boiler greatly exceeded the surfaces of all other parts. By comparison, some of the present-day central station units contain practically no boiler surface and the only part of the unit resembling the original boiler is the drums.

The increase in steam temperature to 900 F, and in some cases to 950 F, has resulted in the superheater becoming a most important part of the steam generating unit. It must necessarily be located in a high gas-temperature zone since the heat required to superheat the steam to these temperatures represents a gas-temperature drop of approximately 900 deg. The absorption of this amount of heat requires a large superheater surface, not only because of the quantity of heat absorbed, but also because of the relatively small temperature difference between steam within the superheater tubes and gas external to the tubes. Furthermore, the superheater, because of the amount of alloy materials required to withstand high metal temperature and pressure, in addition to alloy supports, becomes an expensive part of the unit.

From the standpoint of minimum cost a superheater with minimum surface is desirable, but this requires that it be located close to the furnace in order to obtain maximum temperature difference between steam and gas, that as far as possible the superheater be arranged for counterflow of steam and gas, and that the gas velocity through the superheater be maintained at a high value. This latter requirement involves very close spacing of the superheater elements. However, experience with high-temperature superheaters, involving high gas-entrance velocity and close-spaced superheater elements, has shown them subject to slag accumulations and plugging of the superheater passes. The amount of the accumulation and the operating program required to maintain the passes free of slag depends upon the character of operating load, the effectiveness of the soot-blowing equipment and the slagging characteristics of the fuel.

Actually a superheater could be designed to obtain the desired steam temperature with tube elements widely spaced and with low gas-velocities. Such a design, however, could seldom be justified economically because of excessive costs. Some recent designs are arranged with the superheater in two sections as indicated in Fig. 1. The first is located closest to the furnace and consists of elements widely spaced with a large gas-passage area to obtain low gas velocity. The second section of closely

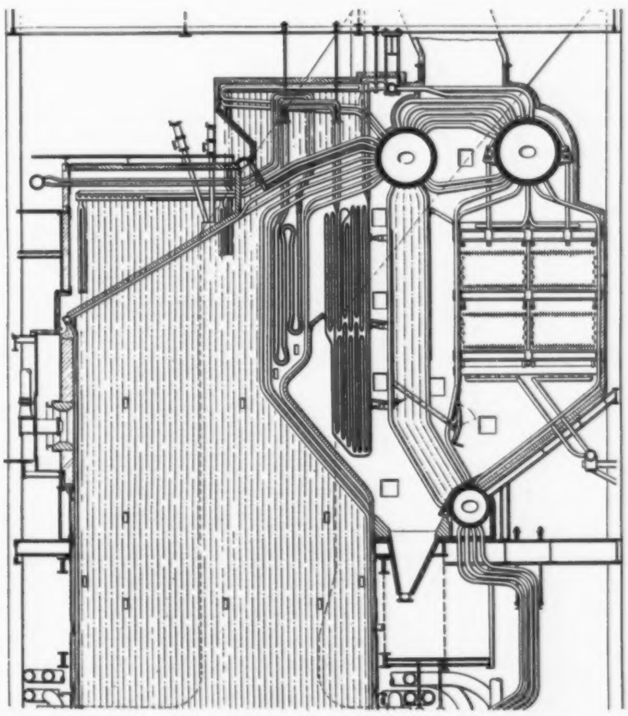


Fig. 1—Design of high temperature unit with superheater in two sections

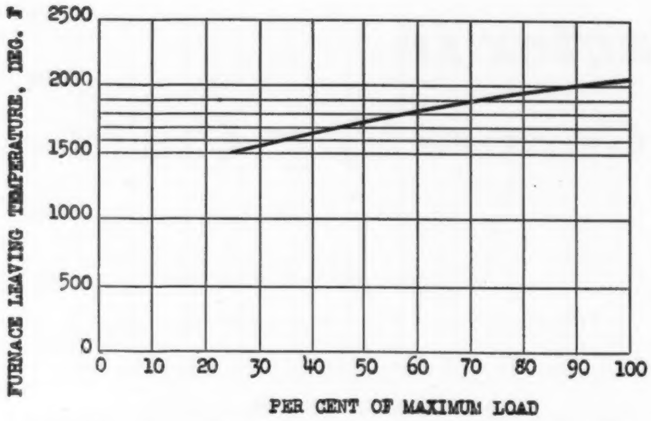


Fig. 2—Variation of furnace exit gas temperature with load

spaced elements is located in a separate pass and the temperature of the gas after passing over the first section is considerably lower than that entering closely spaced tubes in the older designs. This reduces the slag accumulation since the temperature of the gases entering the second, or closely spaced section is reduced below the "sticking" temperature of the ash.

Another part of the steam generating unit which in many cases is affected by the high steam temperatures is the furnace. Most large central station units burning coal utilize this fuel in pulverized form. These furnaces, to eliminate refractory maintenance, are completely water-cooled. It has been found by experience that in order to obtain good combustion conditions, furnace volumes should be large enough to give heat releases, expressed in Btu per cu ft of furnace volume, between 20,000 and 30,000, depending on the character of the coal. But for completely water-cooled furnaces, increasing the size decreases the gas temperature leaving the furnace and entering the superheater. Reducing the gas temperature entering the superheater also reduces the temperature difference in the superheater between gas and steam. A small decrease in the temperature difference necessitates a large increase in the surface and cost of the superheater. In the case of high-ash, low-fusion temperature coals it is extremely desirable to provide large furnaces and reduce the gas temperature entering the superheater to a value well below the fusion temperature of the ash, but to do so would require superheaters prohibitive in size, surface and cost. In such cases some compromise must be made between excessive cost on the one hand and freedom from slag deposits on the other.

The foregoing discussion outlines some of the factors which influence the design of superheaters and furnaces on steam generating units intended for high steam temperatures and high pressures. Moreover, it applies to superheaters of the convection type in which the steam temperature increases with increased evaporation rates on the unit.

It has been shown that steam generating units designed for high steam temperatures require high gas temperatures entering the superheater to reduce the amount of superheating surface. On the other hand, to avoid slag it is desirable to maintain gas temperatures entering the superheater below the fusion temperature of the fuel. With average coals these conditions can be met satisfactorily, providing the steam temperature is specified at or close to the maximum evaporation of the unit.

During the past few years the designers of steam generating units have noted an increased desire on the part of the turbine builders to maintain steam temperatures constant over much wider ranges of the operating load. This requirement has presented the steam generator designer with a far more difficult problem, since under these conditions the superheater must deliver maximum steam temperature at partial load where the furnace temperature is lower than at full load. Fig. 2 is a typical curve for gas temperature leaving a furnace, showing the temperature variation over the load range. It will be noted that if the superheater were required to supply maximum steam temperature at 50 per cent of capacity, the temperature leaving the furnace would be 1730 F, or some 300 deg below that at maximum load. It might be impossible to add enough surface to the superheater to obtain a steam temperature of 900 F or above with this reduced gas temperature at 50 per cent load.

An alternative means of obtaining the desired steam temperature would be to increase the gas temperature entering the superheater. As already explained, this can be done by reducing the size of furnace and sacrificing ideal combustion conditions. Obviously, if the furnace is reduced in size for the purpose of increasing the furnace temperature at partial load, the furnace temperature at maximum load will also be increased. But this is a condition which it is desired to avoid. Whenever controlled high steam temperature is required over more than a small percentage of the load range, it is evident that all of the desirable features mentioned cannot be obtained. Hence, some compromise must be made.

If the proposed installation were to be located in a district where low-grade coals only were obtainable, a user would be justified in investing additional capital in superheater surface for a unit designed to limit the amount of operating labor. On the other hand, if good grades of coal were obtainable, in which case the operating labor required for deslagging the unit would be negligible, then the user could not justify any large additional investment in order to obtain a reduced temperature entering the superheater. Under these circumstances, sacrificing somewhat on furnace combustion space to reduce superheater cost would be in order.

Since controlled steam temperature requires an increase in furnace temperature at the control point above the temperature required without control, the desired advantages might be realized by using large furnaces and providing means to increase the furnace temperature at

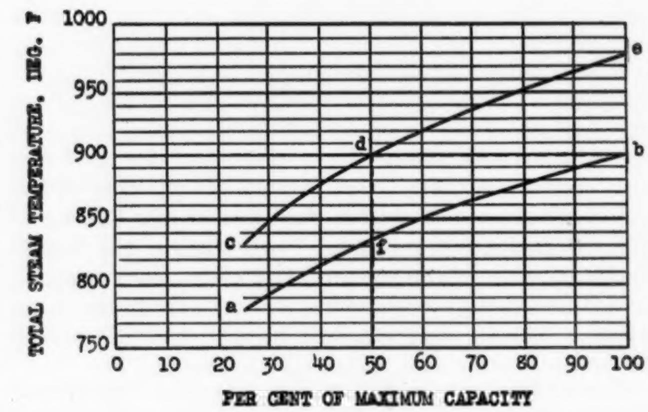


Fig. 3—Curves of superheat characteristics

the control point. Developments along this line have been undertaken. One scheme involves the use of additional burners located higher in the furnace and nearer the furnace outlet than the normal burners. The additional, or auxiliary, burners would be operated at and below the control point only to increase the furnace temperature. A second scheme uses conventional burners but adds an adjustable feature to them. The adjustment allows the flame to be directed upward at partial load when higher gas temperature is desired and directed downward at maximum load where it is desired to reduce the furnace leaving temperature.

To obtain constant steam temperature above the control point, two types of equipment have been used very extensively. With each, the superheater is designed to give full steam temperature at the control point. Above the control point with one arrangement, the steam temperature is reduced to the desired value through bypassing some gas around the superheater by a manual or an automatically controlled damper. Bypassing gas away from the superheater reduces gas velocity and temperature difference at the gas outlet end. Draft loss through the superheater is also reduced. The second method reduces the steam temperature to desired values by desuperheating the over-superheated steam. The desuperheater is usually located between two sections of the superheater. The amount of desuperheating is controlled to maintain the desired steam temperature at the outlet of the section following the desuperheater. The position of the desuperheater intermediate instead of following the superheater avoids steam temperature in any part of the superheater above the final desired value. This, in turn, reduces the metal temperature and reduces to a minimum the amount of alloy material required.

In Fig. 3 the line *ab* represents a convection type curve to give full steam temperature of 900 F at maximum load. At 50 per cent load the steam temperature as shown at *f* is 835 F. If control is desired with constant steam temperature from 50 per cent of load to maximum, the unit must be redesigned to raise the steam temperature at 50 per cent load from 835 F at *f* to 900 F as shown at *d*. The redesigned superheater then has the characteristic curve *cde*. The control apparatus must reduce the temperature from that shown by line *de* to the constant temperature of 900 F as shown by the line *db*.

Many steam generating units designed and equipped with means for controlling steam temperature have been in operation for several years. This experience has proved that the additional expense and complications involved have been fully justified. Most of these installations, however, are arranged for control over only small percentages of the load range, in most cases 25 per cent or less. For this limited range the cost of the superheater although considerably more than without the control is not excessive. Furnaces also can be proportioned with desired large combustion space where control is limited.

The foregoing discussion has attempted to acquaint the reader with those desirable features of the design which must be sacrificed if wide ranges of steam temperature control are required. The fact that all power plant engineers do not fully appreciate these features is evidenced by some specifications requesting high steam temperatures with wide range of control and at the same time specifying furnace size by limiting the heat release.

Port Washington 1942 Experiences

For several years past it has been our custom to publish, each January, an account of the performance and preceding year's operating record of the well-known Port Washington Station, together with accumulative figures of performance since its initial operation. These figures have shown a steady and consistent improvement, although by diminishing increments, as would be expected. For this information we are indebted to M. K. Drewry, Assistant Chief Engineer of Power Plants of the Wisconsin Electric Power Company.

THREE stops, totaling 28 days, comprised 1942 outages. In May the high-pressure turbine section was given its regular 15,000 operating-hour inspection. In accordance with an established plan, 26 more rows of blading having silver-soldered shrouds were equipped with welded shrouds, thus quite well completing this improvement of high-temperature high-pressure blading.

In September, a four-day "week-end" inspection and maintenance outage occurred on schedule. During November, moderate governor-parts vibration caused a two-day week-end outage. Having caused an unexpected stop, though scheduled for a week-end, it was the most important trouble during the year. The boiler and turbine now have nearly equal availabilities of 94.3 and 94.8 per cent, respectively, for the seven years.[1]

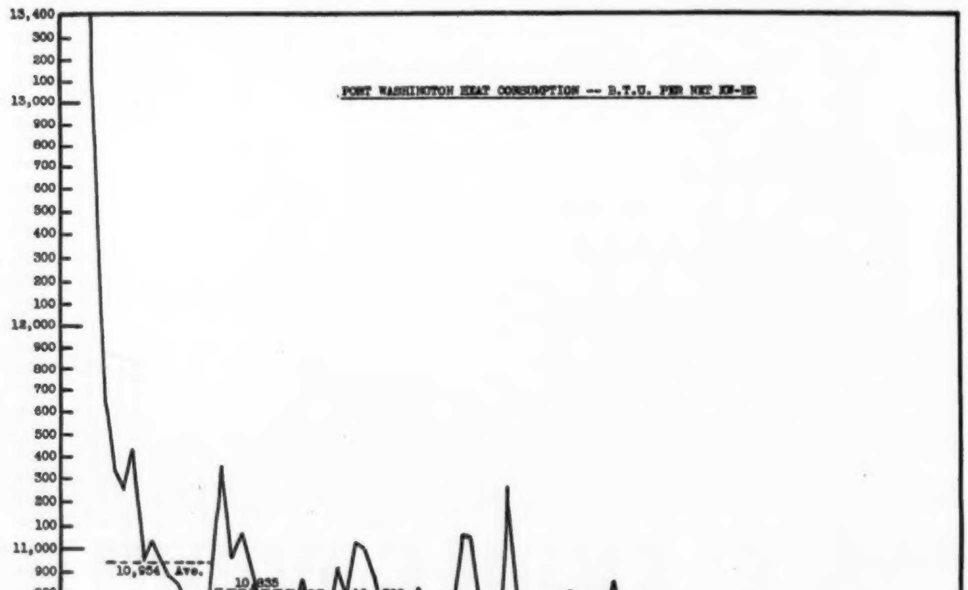
The plant was in operation $92^1/_2$ per cent of the elapsed time in 1942. Inspection and maintenance time was $7^1/_2$ per cent. The table shows the seven-year averages for the plant to be 89.7 per cent operation: 91.2 per cent availability, or, in round numbers, respectively, 90 per cent and 91 per cent.

[1] Design information and earlier operating data are available in the following references; A.I.E.E. paper, June 1933; *Mechanical Engineering*, Nov. 1936; COMBUSTION, Feb. 1938, Jan. 1939, Jan. 1940, Feb. 1941, Jan. 1942.

OUTPUT AND HEAT CONSUMPTION DATA

Year	Month	Net Output, Kwhr	Heat Consumption, Btu per Kwhr Gross	Aux.	Net
1942	Jan.	42,406,530	10,094	542	10,636
	Feb.	38,033,769	10,121	541	10,662
	Mar.	43,704,664	10,071	525	10,596
	Apr.	41,310,069	10,013	531	10,544
	May	18,027,856	10,099	590	10,689
	June	35,177,280	9,993	554	10,547
	July	43,762,510	9,948	530	10,478
	Aug.	46,226,085	10,049	547	10,596
	Sept.	40,511,906	10,089	563	10,652
	Oct.	43,880,244	9,997	537	10,534
	Nov.	40,741,575	10,003	546	10,549
	Dec.	47,747,436	10,154	556	10,710
1942	12 Mo	481,529,924	10,051	545	10,596
1936–42	84 Mo	2,967,081,500	10,188	555	10,743
1935–42	87 Mo	3,005,488,200	10,203	558	10,761

The unbroken downward heat consumption trend was continued by a few heat units per kilowatt-hour, despite appreciable full-load operation. The curve shows net



OPERATING PERIODS AND REASONS FOR OUTAGES—1942

No.	Date Started	Date Finished	Hours Run	Kwhr Generated	Outage Hours	Outage Reason
61*	12/27/41	5/ 9/42	3,192.72	193,316,000	534.40	General scheduled inspection of boiler and turbine. 23 rows of high-pressure spindle blading and 3 rows of high-pressure cylinder blading equipped with welded shrouding
62	5/31/42	9/18/42	2,631.88	168,222,000	89.27	General scheduled inspection of boiler
63	9/21/42	11/13/42	1,277.40	79,470,000	35.40	Turbine governor exchanged. (Scheduled outage)
64	11/15/42	12/26/42†	997.93	66,606,000		
Total	12/27/41	12/26/42	8,099.93	507,614,000	659.07	
Total	11/22/35	12/26/42	55,989.85	3,166,461,500	6,217.15	

* This operating period started 9/7/41.
– Still in operation.

USE & AVAILABILITY DATA

	1942 Boiler	1942 Turbine	1942 Plant	7-Year Average Boiler	7-Year Average Turbine	7-Year Average Plant
Use Factor, $\frac{\text{Service hours}}{\text{Period hours}}$	92.5	92.5	92.5	89.9	89.7	89.7
Hourly Output-Capacity Factor, $\frac{\text{Ave. hourly output}}{\text{Rated hourly output}}$	69.7	78.3	78.3	63.0	70.8	70.8
Annual Output-Capacity Factor, $\frac{\text{Annual output}}{\text{Annual rated output}}$	64.5	72.4	72.4	56.8	63.7	63.7
Annual Demand Factor, $\frac{\text{Demand hours}}{\text{Annual hours}}$	93.5	99.0	100	94.3	96.1	98.5
Demand Availability, $\frac{\text{Service hours}}{\text{Demand hours}}$	98.9	93.4	92.5	95.9	94.1	91.7
Annual Availability Factor, $100 - \frac{\text{Repair hours}}{\text{Annual hours}}$	97.1	93.5	92.5	94.3	94.8	91.2

heat consumption by months and years since initial operation in late 1935.

Seven years of good economy without evidencing a loss trend possibly represents a new characteristic of modern power stations, indicative of long life with low maintenance.

As in previous years, the Wisconsin Electric Power Company has made available to us a number of mimeographed copies of the "Averages of Daily Operating Data" which will be supplied to interested readers upon request.—EDITOR.

Electric Watchman Protects Turbine-Generator

A Westinghouse research engineer, H. C. Werner, has developed an automatic electric watchman, about the size of a large box camera, which jots down on a chart a warning in red ink when it detects vibrations that might eventually lead to the crippling or extended outage of a turbine-generator—an occurrence that is to be carefully guarded against, particularly at this time when so many units run at 3600 rpm and when all available capacity is urgently needed for war production.

The device consists of a babbitt-tipped rod that touches the rapidly revolving shaft, and a coil attached to the upper end of the rod is thereby displaced with relation to an electromagnet. This produces an electrical impulse equivalent to about one-millionth of a watt which is stepped up by an amplifier to two or three watts—sufficient to operate the recorder that pens the vibration curve. It is essentially a midget-sized electric generator.

Axial Displacement Also Recorded

Steam turbine rotors often expand axially as much as three-quarters of an inch, when put in operation after a period of idleness. To allow for this expansion, one end of the turbine rotor is anchored to the foundation, while the other end is permitted to slide freely in an endwise direction. This expansion must be uniform within the designed clearances to avoid rubbing and possible damage. Hence, Mr. Werner has also developed an instrument to detect and record axial displacement of the shaft relative to the stationary parts. A disk attached to the shaft is located approximately one thirty-second of an inch from a magnetic coil which is connected by means of a low potential circuit to a meter. If the shaft and the attached disk move horizontally the slightest amount, the air gap between the disk and the coil changes, and this alters the voltage which is reflected in the meter. A recording pen shows the rate of expansion, together with any abnormal condition that may develop.

These devices, although differing in design, are analogous in purpose to some of the turbine-supervisory instruments described in a recent paper before the A.S.M.E. by Messrs. Roberts and Dimond of the General Electric Company.

Analysis and Testing of Coal

Following are excerpts from a lengthy and comprehensive paper by A. C. Fieldner, of the U. S. Bureau of Mines, which was presented before the Institute of Fuel, in London on October 13 on the occasion of the award of the Melchett Medal to the author. Owing to his inability to be present, the author delivered the address before a recording film in this country and the film was sent to London where it was thrown on the screen during the meeting. In the absence of Doctor Fieldner, Mulford Colebrook, of the U. S. Embassy, received the medal on his behalf from President Selvey of the Institute of Fuel. The medal was then dispatched to the United States and presented in person to Doctor Fieldner, by President Selvey's son, at the recent Annual Dinner of the A.S.M.E. The complete paper covers a review of the work of the U. S. Bureau of Mines in fuel technology from its inception to the present and contains many charts and tables.

ESTABLISHMENT of the Coal Testing Plant of the U. S. Geological Survey at the Louisiana Purchase Exposition in 1904 marked the beginning of organized fuel investigations on a national scale. The work was continued after the Fair, and in 1910 was assumed by the newly established Bureau of Mines, which ever since has devoted a major portion of its staff and facilities to fuel-testing and research.

Early History of the Testing of Coal

The first step toward national standardization of the empirical proximate analysis of coal was taken by the American Chemical Society in the appointment of a committee headed by Professor W. A. Noyes. In 1898 this committee recommended standard methods for the proximate analysis of coal. These procedures had their first large-scale application to a wide variety of coals, ranging from lignite to anthracite, at the testing plant in St. Louis. Here, it was discovered that these methods were inadequate with respect to the determination of moisture and volatile matter, especially when applied to subbituminous and lignitic coals, which contain large percentages of moisture. Difficulty also was experienced in obtaining reproducible results in dealing with high-moisture bituminous coals.

Investigation showed that in the American Chemical Society method of drying coal for an hour at 105 C, in an ordinary oven, the partial pressure of water vapor in the oven varied according to the natural circulation of air in the oven and the amount of moisture given off by the samples. Consequently, the coals dried to different equilibrium points depending on the amount of water vapor in the oven atmosphere. Concordant results were obtained by providing a positive circulation of dry air through the moisture oven so as to maintain a negligible pressure of water vapor in the oven atmosphere.

The variable volatile-matter results were found to be due to mechanical loss (usually designated as "sparking") of particles of the sample ejected from under the lid of the crucible by rapid evolution of volatile matter in the normal method of rapid heating.

A gradual preliminary heating at such a rate as to prevent "sparking" proved to be a fair but not a complete solution of this problem in all instances.

With these principal modifications of the American Chemical Society methods, the U. S. Geological Survey Fuel Testing Plant conducted the Coal Investigations reported in Professional Paper 48 of the U. S. Geological Survey. These include proximate and ultimate analyses and calorific values determined with the bomb calorimeter of face samples taken in the mines and carload samples delivered at the fuel-testing plant for full-scale boiler and gas-producer tests and, in some instances, washing and briquetting tests.

The next important defect in the then standard method for proximate analysis, strangely enough, did not become evident until 1909, shortly after the fuel-testing plant was transferred to Pittsburgh. On making certain check analyses of duplicate samples in the Washington and Pittsburgh laboratories, it was noted that the percentages of volatile matter determined at Pittsburgh were 1 to 2 per cent lower than those determined in Washington. Investigation showed that the natural gas flame used at Pittsburgh had a lower temperature than the manufactured gas flame used in Washington. A 20-cm flame, as specified by the standard method, was used in both laboratories, but the temperatures were different and the volatile matter evolved was not the same. To avoid these variations, the Bureau of Mines, in 1913, adopted 950 C ($\pm$ 20 C) as the standard temperature and a 10-cm^3 platinum crucible with inserted capsule cover as the standard crucible.

The obvious need of more definite specifications for conducting the proximate analysis of coal led to the formation of a joint committee on Coal Analysis of the American Chemical Society and the American Society for

Testing Materials. In 1913 this committee recommended improved standards for the proximate analysis of coal and new standards for ultimate analysis and calorimetric tests.

Fusibility of Coal Ash and Clinker Formation

The first new test to come to the attention of the Committee on Coal and Coke was the fusibility of coal ash as a measure of the probable clinkering properties of ash in boiler furnaces.

The Bureau of Mines undertook this investigation in 1915 and made a comprehensive study of the effect of various factors, such as the fineness of the ash, the completeness of its oxidation, the rate of heating, the form and method of deformation of the test piece into which the ash was molded, and the oxidizing or reducing nature of the atmosphere in which it was heated. The last factor proved to be most significant in causing wide variations in fusion temperature because of the oxidation or reduction of the iron constituents of the ash. This shows a high fusion temperature in pure hydrogen owing to reduction of iron oxide to metallic iron; a similar high softening temperature in 100 per cent water vapor owing to the iron oxide remaining for the most part in the form of ferric iron or magnetite; and a lower fusion temperature in the middle zone in atmosphere ranging from 70 to 30 per cent hydrogen, where most of the iron is reduced to fusible ferrous silicates. Analyses of a number of clinkers from boiler-furnace fuel beds showed that the iron in these clinkers was chiefly in the ferrous state. Therefore, it was decided that a mildly reducing condition favoring ferrous iron formation should be the standard atmosphere for ash-fusion determinations. This method was thereafter used by the Bureau of Mines and subsequently adopted by the American Society for Testing Materials and later in somewhat modified form, by the British Standards Institute.

The next problem was to determine the relation of the softening temperature of coal ash to the formation of clinker. Obviously, the conditions of the test are not identical with practical conditions. In the test, the ash is finely ground and intimately mixed. In a fuel bed, the ash-forming impurities are not well-mixed, and clinkers may form from segregated groups of mineral impurities. Furthermore, the fusion or clinkering process is not a true melting of a definite compound, but the gradual formation of a fusible slag from parts of the ash. This slag carries in it more or less unmelted constituents. For this reason, any close relationship is not to be expected, although ash-fusibility tests have considerable general value in assessing probable clinkering properties of coals.

Viscosity of Coal-Ash Slags

With the advent of the slag-tap type of furnace, Nichols and Reid of the Bureau of Mines turned their attention to a study of the properties of coal-ash slags representing a higher degree of fusion than that normally experienced in the formation of fuel-bed clinkers. In their early investigations, they sought to utilize the heretofore neglected fluid-temperature observation of the Standard Ash-Fusion Test. This observation was found to have some value. Simple viscosity tests also were made by heating the ash in platinum crucibles to the point where it could easily be stirred with a platinum rod held between the fingers. Useful data were thus obtained, and the results were published in a series of papers. This work showed the necessity for a really comprehensive program of research involving determination of the true viscosity of coal-ash slags at various temperatures in oxidizing and reducing atmospheres and of relating these data to the chemical composition of the ash.

Viscosity in absolute units can be measured only with true liquids. The presence of a solid material dispersed in a liquid changes the properties of the liquid so that the rate of flow is no longer strictly proportional to the applied stress. These mixtures of liquid and solid phases may be referred to as "plastic" and the flow as "plastic flow." Coal-ash slags exhibit this property and may behave as viscous liquids at high temperatures and as plastic liquids at lower temperatures. The transition between these two conditions occurs at the "liquidus" temperature, where, on cooling, a solid phase separates from the liquid slag and the rate of flow for a given stress suddenly decreases. At temperatures higher than the liquidus temperature slag is a true liquid, and measurements of viscosity can be made independent of time. Below the liquidus temperature, the "apparent" viscosity depends not only on the viscosity of the liquid phase which is still present but also on the quantity and the dimensions of the solid particles. When a slag is cooled to a fixed temperature below the liquidus temperature, the apparent viscosity usually increases with time owing to increase of quantity or size of solid particles.

Reducing atmospheres affect the viscosity of coal-ash slags. The viscosity in the liquid region is unaffected by change in the atmosphere and for slags of low equivalent ferric oxide (Fe_2O_3) content the properties of the slag are much the same, irrespective of change in atmosphere. For high equivalent ferric oxide (Fe_2O_3) slags the viscosity in the liquid region is unchanged by reducing as compared to oxidizing conditions, but the liquidus temperature is lowered considerably by the reducing atmosphere. Thus these slags will separate a solid phase and become plastic at temperatures several hundred degrees lower when reduced than when oxidized.

The Bureau of Mines has embarked on an extensive investigation with a view to obtaining data on the viscosity of ash slags as related to chemical composition of the ash and the results indicated by ash-fusion tests by the present standard method. Viscosity data are directly applicable to the problem of ash removal from slag-tap, pulverized-coal furnaces. It is now possible to predict, for slags of widely differing composition, the relative ease of tapping in a given furnace. The adherence of slag to heat-absorbing surfaces is a major problem of furnaces at high ratings, and information on the flow properties of slag will assist in its solution. When the conditions existing in fuel beds can be precisely stated, viscosity data will assist also in explaining clinker formation, particularly the "sheet" clinker formed at high ratings. Thus, ultimately, it is hoped that clinkering and slagging problems in the use of fuels under various conditions can be solved and prevented.

Gas-, Coke- and By-product-Making Properties of Coals

Next to the direct use of coal as a fuel by combustion, the manufacture of gas and coke is the most important present-day utilization of coal. The selection of coals

for these processes and their intelligent control require not only the standard methods of proximate and ultimate analyses, but numerous other tests as well. In fact, the proximate analysis itself is a simple carbonization test in which a rough indication of the relative proportion of solid residue and volatile matter or gases is obtained. Likewise, examination of the crucible residue shows whether the coal is of a coking or non-coking nature. However, a study of the properties of coals pertaining to the production of gas, coke and by-products is a complex problem that requires extended experimentation for its solution. Workers in these industries have from time to time devised small-scale gasification and coking tests on samples ranging: rom a few ounces to several pounds of coal. Some of these tests yield useful data when interpreted in the light of experience with similar coals in plant equipment. But tests with such small quantities of coal do not yield sufficient amounts of carbonization products to determine their quality as well as their quantitative yield. For these reasons and others, a committee of the American Gas Association in 1927 asked the Bureau of Mines to develop a suitable standard test (designated as the BM-AGA test) for the gas-, coke- and by-product-making properties of coals and to apply this test in a survey of American coals.

It was not expected that the results attained by test would approximate in every respect to those in a commercial plant. The yield and quality of the gas, coke and by-products are conditioned by the temperature of carbonization, the rate of heating, the charging density and the temperature and time of exposure of the volatile matter before it is cooled to a point where no further reactions take place. These factors vary with operating conditions and oven or retort design.

Comparative Results

In comparing BM-AGA test results with those of commercial plants using coal from the same mine but not the identical lot of coal, the following relations were shown:

1. Most of the plant yields of coke, gas and Btu of gas per pound of coal fall between the results obtained at carbonizing temperatures of 900 C and 1000 C; the gas data agree more closely with the 1000 C results and the coke yields with the average of the 900 C and 1000 C results.

2. The total yields of the light oil scrubbed from the gas plus that distilled from the tar in the 900 C tests is approximately the same as the light oil obtained at the plants.

3. The yields of tar obtained in the 1000 C BM-AGA tests show better agreement with plant yields than the tests at lower temperatures, although in several comparisons the plant yields are one to two gallons per ton of coal less than those from the test apparatus using the 13-in. retort; the 18-in. retort, in general, gives better agreement, but, on the whole, the tar yield of the test retort is slightly more than is obtained from by-product ovens.

Determination of Softening and Swelling Properties

When a coking coal is heated at a moderate rate in the absence of air it gradually softens, coalesces and swells, giving off gases and vapors; it then hardens to form a cellular structure in the case of coking coals. Different coals show marked distinctions in the degree to which these plastic and swelling characteristics are shown, and even for the same coal the magnitude of these observations is affected greatly by the particular conditions under which such properties are determined. The transient nature of the plastic state of coal makes it especially difficult to measure the degree of consistency of the partly fused mass and the temperatures of this "plastic range."

When a cylindrical briquette or charge of granular coal is heated in the Agde-Damm or the Sheffield Laboratory coking apparatus from room temperature at a constant rate of temperature rise, it first expands slowly until it reaches about 300 to 400 C, depending on the nature of the coal, when it begins to soften and contract. The point where significant contraction begins on the dilatometer is called the initial contraction or softening temperature. Incipient softening is occurring during the contraction range.

On further heating the coal again expands, owing to increased softening of the coal and the evolution of gases within the plastic mass. This point, called the initial expansion, initial swelling or initial fusion temperature, is shown fairly well by the Agde-Damm and the Sheffield tests. It ranged from 380 to 420 C for most of the high-volatile coking coals tested in the Bureau survey, but ranged as high as 460 C for low-volatile coals.

As the temperature is increased during the plastic or fusion period, the softening mass of coal becomes more plastic or fluid and reaches a maximum indicated by cessation of expansion in the Agde-Damm test, by a minimum torque in the Davis plastometer following the higher resistance to turning caused by the initial fusion of the coal, and by a maximum speed of rotation of the stirring shaft in the Gieseler apparatus. This point is called the temperature of maximum plasticity or maximum fluidity.

As heating is continued and carbonization of the coal proceeds, the plasticity decreases and eventually all of the material becomes solid. This point is termed the final solidification temperature.

A study of the large amount of data obtained in the survey of the coking properties of American coals has not yielded any precise relationships between plastic properties and physical properties of the coke obtained, but a general correlation is evident between the degree and temperature range of plasticity of the coal and the shatter and tumbler indexes of the coke produced.

Plastic-range tests also show the effect of storage and oxidation of coals on their coking properties. Oxidation of a Pittsburgh-bed coking coal for 1244 hr at 30 C decreased the plastic range from 118 to 100 deg and the range of "maximum fluidity" from 35 deg to 19 deg. Oxidation also decreases markedly the "fluidity" or plasticity of coals as measured by the Gieseler plastometer. The treatment of a high-volatile Upper Freeport coal with pure oxygen for 13 days, at approximately 100 C, reduced the maximum fluidity of the plastic coal from 800 Gieseler units to 11 units; similar treatment of a low-volatile Pocahontas No. 3 bed coal for 11.8 days reduced the maximum fluidity from a value of 18 units for the unoxidized coal to 0.8 for the oxidized coal.

Mott, in his recent paper on "The Caking and Swelling Power of Coal" (*Fuel*, 21, pp. 51–61, 1942), has called attention to the outstanding importance of these properties in the carbonization of coal in gas retorts or coke ovens and in the combustion of coal in furnaces. To

these uses may be added the complete gasification of coal in the manufacture of water gas or producer gas. In such equipment the plasticity and the extent of fusion of the lumps of coal profoundly affect the capacity of the equipment and the performance of the fuel bed. Mott uses the term "agglomerating power" to define the ability of a coal to yield an agglomerated or caked coke button in a crucible test, such as the British Standards crucible swelling test, or that used to determine volatile matter. This practice accords with that of American and Canadian fuel technologists as adopted in the Specifications for the Classification of North American Coals. Non-agglomeration is a requisite physical property of semi-anthracite to differentiate it from low-volatile bituminous coal; this property also is used in differentiating between high-volatile bituminous coal and subbituminous coal. A coal is defined as non-agglomerating when the residue from the volatile-matter determination neither forms an agglomerate button that will support a 500-g weight without pulverizing nor a button that shows swelling or cell structure.

Petrographic Analysis of Coal and Its Application

The final topic of this paper relates to the petrographic analysis of coal and its application in the carbonization and hydrogenation of coal. In the Bureau of Mines survey of the carbonizing properties of American coals, a systematic microscopic examination was made of a vertical section of the coal bed at the point where the carbonizing sample was taken. Knowledge of the petrographic composition was found to be helpful in explaining variations in the coking properties of coals that were not evident from the proximate or ultimate analysis. In some instances, such examination pointed the way toward material improvement of the quality of the coke by rejecting a certain bench of the coal bed. A more specific application of petrographic analysis was in the estimation of the amenability of coals to hydrogenation and liquefaction by the Bergius process. The Bureau's survey of the hydrogenation properties of American coals follows essentially the same procedure of batch and continuous hydrogenation testing as was developed by the Fuel Research Station. It is unique in covering a large range of coals ranging in rank from peat to low-volatile bituminous coal. In attempting to correlate the chemical analyses and the rank of the coals, it was found very helpful to use the petrographic analyses of the coal in estimating the unliquefiable residue and predicting the yield of oil obtainable.

Presentation of the Melchett Medal in London by President Selvey of the Institute of Fuel (right) to Mulford Colebrook of the U. S. Embassy (left).

Dr. A. C. Fieldner (center) receiving the medal from Mr. Selvey's son (left) at the A.S.M.E. Annual Dinner, while President Parker (right) looks on.

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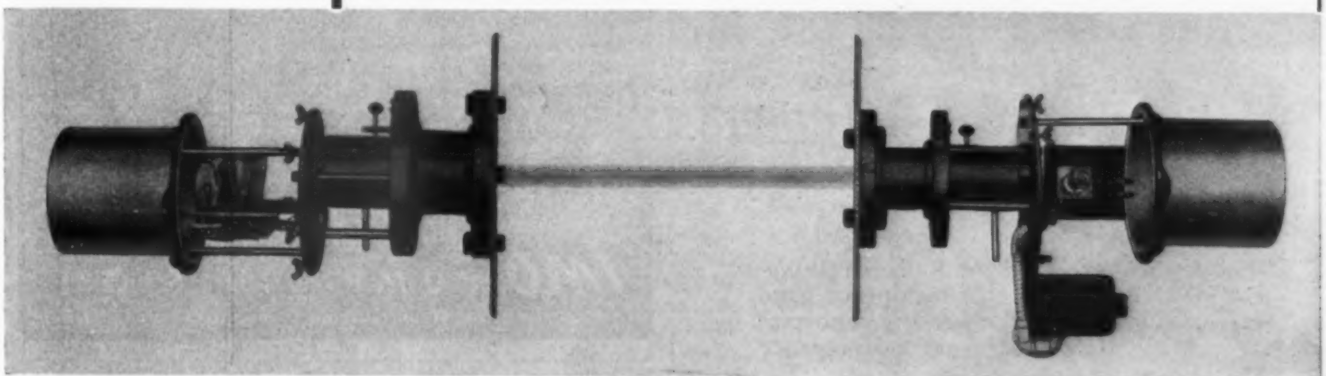

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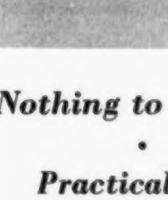

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Disapproves Regimentation of Technology

The December issue of *Professional Engineer*, the official publication of the American Association of Engineers, expresses sharp disapproval of the compulsive features of Senate Bill 2721, the "Technological Mobilization Act," sponsored by Senator Harvey M. Kilgore of West Virginia. The measure would create an Office of Technological Mobilization and direct it to locate all scientifically and technically trained research and development men, appraise the use being made of their services, and to draft all such personnel who fail to submit or to accept plans for immediate conversion of their efforts to work deemed more essential by the Office of Technological Mobilization. Parallel powers over all technological facilities, such as school laboratories, industrial research and development units, etc., are also conferred.

It is asserted that despite the arbitrary powers which the Office is directed to assume in regard to technological men and facilities, and in regard to inventions, patents and secret processes (which the Office is authorized to acquire for "reasonable" compensation and license to other producers), the Office is not given comparable powers over the activities of other government agencies engaged in research and development, and is not authorized to insure eventual utilization of its findings by the War Production Board or by the Armed Forces.

As outlined in the bill, the Office of Technological Mobilization, says the Association, follows too closely the plan of technological mobilization set up in Germany in the ten years preceding the outbreak of war. It represented the subordination of technology to a bureaucracy rather than mobilization.

If the measures prescribed in the Act would in truth guarantee an immediate and full utilization of technological resources in the winning of the war, the professions would offer no opposition. Appraising S2721 strictly as a war measure, the Association points out the enormous organizational difficulties involved, particularly serious because they must in some degree impede the war effort—necessitating readjustment or reorganization of many agencies, without really achieving integration. Hearings on the bill, says the Association, develop the fact that the Office of Scientific Research and Development has spent seventy million dollars, and found it necessary to restrict its efforts to a very small phase of the work allotted to the Office of Technical Mobilization, capitalized at $200,000,000.

It is the peacetime implications, however, that the American Association of Engineers finds so disconcerting. The Act authorizes the office to function for a period of ten years (until 1952) and among its purposes states that it is intended to "make forever secure America's world leadership in the practical application of scientific discoveries." The powers conferred on the Office of Technological Mobilization to control technically trained men, technological facilities and industries (through right to investigate all research and development projects and acquire rights to use and license such processes) are drastic even in war, and in peace are revolutionary. They amount to establishment of bureaucratic control over the agents and instruments of production, says the Association, which makes this Act the bridgehead of forces that could invade free enterprise and bring all industry under bureaucratic control.

The American Association of Engineers proposes instead free professions—integrated in state societies, in turn united in a national association—to make the full technological resources of the nation available to the war effort and to serve as a great communications network for the private enterprise system in the post-war period.

Secretary Ickes Demands Longer Hours for Miners

Solid Fuels Coordinator for War, Harold L. Ickes, has made public identical letters in which he has asked representatives of the workers and operators in the bituminous coal mining industry to settle their controversy and act at the earliest possible time to carry out his request of September 29 to lift the present 5-day 35-hr weekly limitation on the hours of labo in the mines.

The letters were addressed to John L. Lewis, President of the United Mine Workers of America, and Ezra Van Horn Cleveland, Ohio, Chairman of the Appalachian Joint Conference, an operators organization, and were as follows:

"On September 29 I requested the mine operators and the employees of the coal industry to lift the present 5-day 35-hr weekly limitation now imposed upon mine working time under the industry's wage agreements.

"At the time I made this request, I emphasized that expeditious action was necessary to assure an adequate supply of coal for military and essential civilian needs.

"Now, more than two and a half months after this request was made, I have been officially informed that the bituminous coal operators and their employees have broken off negotiations after failing to agree on certain details, and that the operators have referred the disputed points to the National War Labor Board.

"The failure of the mine operators and their employees to reach a speedy decision is a distinct disappointment, particularly in view of the fine record your industry has maintained up to now in meeting its war responsibilities. The Nation will need an unprecedented amount of coal to speed the winning of this war, and if it is not supplied the war will be prolonged at the unnecessary cost of human lives and suffering. Now that our armed forces are fighting the African and Pacific campaigns, and are intensifying their drive to speed the final victory, your responsibility to provide sufficient coal to make possible the attainment of their objectives has greatly increased.

"Neither your industry nor the transportation system will be able to meet the Nation's coal requirements under the present restrictions that limit mine workers

to five 7-hour days of labor per week. The relatively secure position to which our present coal supply has been built will be quickly lost unless the mining industry can utilize its manpower and facilities more fully. Also, vital transportation facilities will be wasted.

"Obstacles to speedy settlement of this matter, which once were presented by Government regulations covering maximum bituminous coal prices and the rates of pay for increased hours of labor, have been removed. The way is now clear for speedy action, and the Nation expects it.

"As Solid Fuels Coordinator for War, I am concerned only in obtaining an adequate coal supply. As I told you at the time I made the original request, I expected the operators and the workers to decide all of the details of executing this request and to do so expeditiously. I understand that certain progress has been made in reconciling workers' and operators' points of view, in which controversies I have not and do not wish to intervene, but an agreement to extend the working week in the mines has not been reached. Workers' and employers' organizations have a recognized function to perform such tasks in wartime. That is your responsibility.

"In the interest of maintaining the fuel security of the Nation, I shall expect both parties to this controversy to settle their differences at the earliest possible moment. Too much precious time already has been unnecessarily wasted."

Government Needs Engineers

Education and experience requirements for engineers have been lowered to meet the increasing need for filling engineer positions, the Civil Service Commission has announced.

For the grades of Assistant Engineer, $2600 a year, through Chief Engineer, $8000 a year, applicants either must have successfully completed a full four-year course leading to a bachelor's degree in engineering in a college or university of recognized standing; or must show professional engineering experience providing the substantial equivalent of such a course, in addition to the required experience.

One year of professional engineering experience, or of engineering graduate study, is required for Assistant Engineer at $2600 a year. For higher positions applicants must show additional experience of a progressively higher level—higher in degree of difficulty and importance of work performed, amount of responsibility assumed and extent of supervision exercised. Graduate study will be accepted on the same basis as experience, except that, in general, graduate study alone will not be considered qualifying for grades above $3200.

Most of the positions are in the grades paying $3800, $3200 and $2600 a year, and only a few positions will be filled at the higher salaries. It is contemplated filling positions in Washington, D. C., throughout the United States, and in its territories and possessions.

Applications will be accepted until further notice, but qualified persons are urged to apply immediately. No written test will be given, and applicants will be rated on the basis of their statements in the applications, subject to verification by the Commission. Applications will be rated as soon as possible after their receipt at the U. S. Civil Service Commission, Washington, D. C.

TVA Reports

Reporting to the President and Congress for the fiscal year of 1942, the Tennessee Valley Authority stated that it had increased its electric generating capacity by almost a third, to 1,374,500 kw, and had now become one of the largest power producers in the United States, with production at the rate of nearly ten billion kilowatt-hours annually. More than 70 per cent of the power is at present used in war production, largely for the great electrometallurgical and electro-chemical plants in that region.

During the fiscal year, ending in June 1942, the TVA commenced construction on eight dams and continued work on three others. Four dams and a large steam plant were placed in service, and 500 miles of transmission lines were built. Also, a major interconnection with power systems to the north was effected, making possible more efficient use of power facilities in the TVA and adjoining areas.

The Watts Bar steam plant was placed in operation in 18 months from the time of its authorization and it is being enlarged at present.

Gross revenues from operations were $25,329,954, and the net operating income, after depreciation calculated on a straight-line basis, payments in lieu of taxes to the states of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Tennessee, and to their counties affected by the TVA program, was $1,859,416. Investment in power plants alone approximated $283,000,000.

The average use of electricity by residential consumers continued to rise to 1520 kwhr per customer per year, which was 50 per cent above the national average of 1109 kwhr. The average cost of electricity to this class of consumers is 2.02 cents per kilowatt-hour.

A. D. Bailey Advanced

Alex D. Bailey, chief operating engineer of Commonwealth Edison company, was advanced to the position of assistant to the vice president in charge of operation and engineering on January 1. He will assist Vice President H. B. Gear in the administration of the departments under his direction and will have general supervision over Powerton Generating Station and its related transmission system.

Paul B. Juhnke, assistant chief operating engineer, was promoted to Mr. Bailey's former post and Mr. Juhnke was succeeded by Arthur E. Grunert, who will also continue for the present as superintendent of generating stations. Uriah Davis, assis-

tant chief load dispatcher, was appointed chief load dispatcher.

A veteran of 39 years of service with Commonwealth Edison Company, Mr. Bailey is widely known throughout the electrical industry. He started his utility career in 1903 as a draftsman at Harrison Street Generating Station and rose through the ranks to chief engineer at Fisk and Quarry Stations, superintendent of generating stations and assistant chief operating engineer. He was elevated to chief operating engineer in 1936.

Obituaries

David C. Johnson, Vice President of the Consolidated Edison Company of New York, died of a heart attack on December 19, at the age of fifty-seven.

A native of Brooklyn and a graduate of Stevens Institute of Technology, Mr. Johnson began his public utility career as a construction engineer with the Astoria Light, Heat and Power Company and later became associated with H. De B. Parsons in various construction projects. He was subsequently with the National City Company for a period of ten years, as manager of its public utility department, and in 1927 joined the New York Steam Company of which he was president when that company was taken over by the Consolidated Edison Company.

Albert Kahn, well-known architect and engineer of Detroit, died at his home on December 8. Born in Rhaunen, Germany, March 21, 1869, he came to the United States at the age of eleven and soon thereafter secured his first job as an errand boy in an architect's office. From then on his success was a matter of applying study, hard work and perseverance culminating in the formation of Albert Kahn Associated Architects and Engineers, Inc.

During World War I, he laid out many cantonments, naval bases and air fields and during the present conflict, he and his associates have been responsible for the design of such plants as the Detroit (Chrysler) Tank Arsenal, the Wright Aeronautical plants, the Ford Bomber plant, the Glenn L. Martin, Curtiss-Wright and Pratt & Whitney and numerous other war plants, as well as naval bases at Midway, Honolulu, Alaska, Puerto Rico and other points.

W. S. Barstow, former President of General Gas & Electric Corporation and, for many years, prominent in the electric utility field, died at his home in Great Neck, L. I., on December 27, at the age of 76. He was one of the electrical pioneers in this country, being associated in the early days with Thos. A. Edison, and helped in the establishment of electric plants in many sections of the country. In 1906 he organized the electrical engineering firm of W. S. Barstow & Co. which later, through its subsidiary, the General Gas and Electric Corporation developed, operated and managed a large group of utilities in eight eastern states. At the time of his death he was a partner in the firm of Barstow, Campbell & Company.

Nicholas Stahl, Chief Engineer of the Pennsylvania Power and Light Company since 1928, died January 1 in the New Haven, Connecticut, General Hospital at the age of 66. He was born at New Castle, Del., and was graduated from Princeton University in 1897. From 1907 to 1918 he was an engineer for the Westinghouse Electric and Manufacturing Company and later was connected with the Narragansett Electric Company of Providence, R. I.

A. D. Skinner, for the last twenty years president of the Skinner Engine Company, died at Erie, Pa. on December 4, after a brief illness at the age of 68. For forty-seven years he had been associated with this company which was founded by his father, the late Le Grand Skinner. He was well known as a designer and builder of steam engines for both stationary and marine service.

Oil Now Permitted for Coal Spraying

The OPA has recently amended the fuel oil regulations to permit its use for coal spraying under certain specified conditions until the end of March. These conditions are as follows:

Spraying must be done at the mine; the coal to be sprayed must have been screened through not larger than a $1^1/_4$-in. round hole, or its equivalent; the quantity of oil must not exceed one quart for each ton of coal sprayed; and the coal is to be shipped only to points outside of South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, Texas, New Mexico, Arizona, Oklahoma and California.

The granting of these limited rations for coal spraying is advisable in the opinion of OPA, as the process prevents the freezing of coal into a solid mass during transportation and thereby reduces unloading time.

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